Do Empirical Trade Findings Require a New Theory of Economic Growth

Dr M. J. Cadbury

University of Hertfordshire

UK

Abstract

Empirical cross-country analysis of trade consistently shows a strong link between the openness of a country's trade policy and that country's economic growth. There are clear difficulties inherent in any such study in separating out the effect on growth of one particular factor, in this case isolating the influence of trade policy. Previous work in this area has also been hampered by lack of data, usually requiring averaging over decades, and uncertainty over how trade policy might be measured. This study makes use of a larger dataset allowing annual observations and makes improvements in the measurement of trade policy and the methodology of linking it to growth. The results are in line with previous work and confirm that trade openness has a strong link to income growth.

Since the first mathematical growth equations of Solow and Swan, technology has been seen as the ultimate driver of economic growth working through land, labour and capital. Subsequent work has focussed on how technology might arise, whether at a set rate, exogenous growth, or driven by deliberate investment, endogenous growth. However it isn't obvious how trade might influence either of these equation forms. Nordas et al (2006) set out four possible mechanisms by which trade might have a growth effect and conclude that the mechanism of technology spill-over gives the best explanation for dynamic gains from trade. This conclusion is not entirely satisfactory and neither is it well supported by empirical research.

This study suggests that it is necessary to re-examine the basis of growth theory to account for the effect of trade. The proposal is that the technology term in growth equations be replaced by a term which encompasses both technology and specialisation, and that it is through the specialisation element of this term that trade has its major influence on growth.

1.0 Introduction and Literature Review

The historical record suggests that trade has been a major factor in country development, with trading nations frequently achieving increased income levels. Economic theory, however, has been more equivocal about the benefits of trade. The early Mercantilists believed that countries should maximise their holdings of gold and so recommended barriers to imports and encouragement to exports. Most countries at that time followed this approach. Smith (1776), by contrast, made it clear that trade would be beneficial and that barriers to trade were undesirable. Ricardo (1817) showed how rich and poor countries alike could benefit from trade through the mechanism of specialisation according to Comparative Advantage. Led by Britain with the repeal of the Corn Laws, many European countries opened up to trade in the mid nineteenth century. However the support for trade opening was not unanimous and the USA took a different path after the US Civil War, based on the thinking of Hamilton. Hamilton's concept was that barriers to imports would force industrialisation and would thus be strategically beneficial for the development of the USA. In the late 19th and early 20th centuries the USA pursue a policy of tariff increases, in due course contributing to the great depression of the 1930's and a general reduction in world trade after other countries followed suit. After World War II the USA worked to reduce trade barriers, however the idea that import restrictions could be useful to drive strategic development has remained an alternative idea to trade based on Comparative Advantage and market outcomes. In particular development economists Prebisch and Singer advocated the use of trade barriers for developing countries in the 1960's and many developing countries still retain high trade barriers today.

Politicians in most countries have sought to reduce barriers to trade, but only if other countries would also do so. In effect politicians behave as if a barrier reduction by a specific country is beneficial to other countries whilst being damaging to the country that reduces the barrier, thinking that is essentially in line with the Mercantilism of 250 years ago. The examples of Hong Kong, Singapore, and latterly China, which reduced their barriers to imports unilaterally and grew rich are generally dismissed as atypical exceptions.

The effect of trade barriers on an economy can be in two distinct forms: one-off "static" effects and long term "dynamic" effects on growth. The theory of static welfare effects has been extensively developed from the original classical models of perfect competition to the incorporation of imperfect competition by Grossman, Helpman and others. The original classical models suggested that barriers to imports would always create a loss of welfare for the country which applied them. The imperfect competition models, by contrast, suggest that there may be situations where barriers to imports can be welfare enhancing. The imperfect competition models show value enhancement from barriers when a country is able to influence prices and also show that mutual reduction of barriers between countries is ideal in this situation (Grossman, 2016).

Dynamic growth effects from trade barriers have proved more difficult to incorporate into economic theory. Early mathematical growth modelling by Solow and Swan used equations with factors of land, labour and capital combined with technology. Initially technology was assumed to be created at a set rate exogenous from the functioning of the model. Romer introduced the idea that technology could also be modelled and based on deliberate investment within the model or endogenous growth. Neither set of models, however, has an obvious way of incorporating dynamic gains from trade. Nordas et al (2006) examined this question and came up with four possible mechanisms by which trade might influence growth, these are shown in Figure 1.1. Nordas et al concluded that the only true growth mechanism from trade was technology spill-over. Technology spill-over would occur either from the acquisition of new technology when developing products for export or from the import of products embodying new technology.

Figure 1.1: Productivity Effects of Trade by Channel (Nordas et al, 2006)

	Channel of productivity gain	Level/Growth effect
1	Better resource allocation	Level
2	Deepening specialisation	Level
3	Higher returns to investment (investment/capita and/or R&D)	Level – long adjustment period
4	Technology spill-overs	Growth

Many empirical studies have looked for a link between trade and growth, Singh (2010) carried out a survey of 61 such studies and found that almost eighty percent of them found statistically significant evidence of a trade to growth link. Only one of the studies made the reverse finding of a positive link between trade barriers and growth (for the period 1875 to 1914) and further work by Schularick and Solomou (2011) has questioned this finding. The empirical studies also tend to show that the effect of trade on growth is considerable.

Singh (2010) also surveyed 44 microeconomic studies looking for evidence of technology, and hence productivity, gain to firms that traded. Of these studies 40 were focused on exporting and just 4 on importing, suggesting that Mercantilist thinking extends even into academic research. Of the exporting studies, 35 showed a link between exporting and productivity gain, however 19 showed evidence that firms with higher productivity were more likely to export, whilst only 16 indicated that exporting led to higher productivity. Of the importing studies all 4 showed productivity gains to firms which imported. Overall the findings on technology spill-over at the microeconomic level are not clear.

Whilst the overall conclusion might be that the macroeconomic studies offer comprehensive support for the existence of dynamic gains from trade, there are problems. The studies use different measures for trade openness, follow inconsistent methodologies and tend to have small sample sizes. Measuring trade policy has proved to be problematic in that countries use a variety of tariffs and other barriers like quotas and regulations. There is disagreement on how to handle measurement, in particular some economists recommend creating complex indices which take into account all types of barriers, whilst others recommend using simple direct measures. Methodologies vary, with cross-country analysis the most frequently used and lack of sufficient data leads to many studies being based on average figures across several years and thus a small number of observations. As a consequence of these issues, the existing empirical literature on dynamic gains from trade cannot be said to be definitive.

2.0 Data

The trade policy data for this study comes from the United Nations Conference on Trade and Development (UNCTAD), who produced a database of trade information going back to 1960. This database, Long Time Series TRAINS, is no longer available. Previous work on this data (Cadbury, 2016) used regressions in a modified gravity equation of different trade policy measures against trade value. This analysis showed that Effective Tariff, which is customs receipts divided by total imports, was the measure of trade policy which correlated best to changes in trade value, this result is shown in Table 2.1.

Table 2.1: Comparison of Performance of Trade Policy Measures (Cadbury, 2016)

Measure	Coefficient in equation with log real trade as dependent variable	t value	p value	R2	Observations	Number of Countries
Effective Tariff	-0.1366	-12.30	0.000 Sign ***	0.93	2685	133
Weighted Average Applied Manufactured Goods Tariff	-0.6519	-3.86	0.000 Sign ***	0.94	1421	151
MFN Tariff	-0.2004	-6.50	0.000 Sign ***	0.93	1877	157
Coverage of Non-Tariff Barriers	+0.3896	+1.76	0.079 Sing *	0.92	1962	154
Trade Restrictiveness Index	-0.5374	-4.69	0.000 Sign ***	0.91	1810	134
Standard Deviation of MFN Tariff	-0.2170	-2.50	0.013 Sign **	0.91	2002	157

Effective tariff also has more observations than UNCTAD's other trade policy variables. One key difference between Effective Tariff and the other measures is that Effective Tariff takes account of tariffs and subsidies on both imports and exports, it is thus the most complete numerical measure of trade policy available. An interesting finding from the above analysis is that UNCTAD's measure of coverage of non-tariff barriers does not perform well. This may be the result of the way UNCTAD calculated this measure, but it may also be that non-tariff barriers provide less of a restriction on trade than is generally supposed to be the case, which would in turn cast doubt on the validity of complex indices which include both the effect of tariff and non-tariff barriers. UNCTAD's Effective tariff has been selected as the measure for use in this analysis, allowing a maximum of 2685 annual observations in a panel regression. This is likely to be an improvement on the data used in previous analyses which mostly relied on weighted average tariff measures averaged over several years.

3.0 Methodology

A consistent problem with analyses of growth drivers is isolating the exact relationship of interest from other factors. Two previous analyses illustrate this point and are summarised in Figure 3.1. A World Bank study (World Bank, 1987) classified countries according to their "outward orientation" and showed that the most outward oriented group outperformed the most inward oriented group on income growth by 5-6% per annum. This study used decade growth averages, the countries were classified qualitatively and there were just three countries in the most outward oriented group, making the average growth differences rather dubious. A later study by Wacziarg and Welch (2003) used a larger group of countries, but again had decade averages and grouped countries according to the Sachs and Warner open/closed classification. The Sachs and Warner classification defines four conditions which must be met for a country to be "open", some of which are more to do with macroeconomic management than trade itself.

Figure 3.1: Selected Trade Policy and Income Growth Studies

Study	Time Periods	Number of Observations	Openness Measure	Scaling of Measure	Dynamic Gains Identified
World Bank (1987)	Decade Averages	82	Trade/ Macro-economic	Qualitative	5-6% Income Growth difference between Strongly Outward Oriented and Strongly Inward Oriented
Wacziarg and Welch (2003)	Decade Averages	249	Trade/ Macro-economic	Open/ Closed	1.5% Income growth difference between open and closed

The larger dataset in this study makes it possible to use a panel with annual figures and the Effective Tariff measure is clearly focussed directly on trade. A further methodological enhancement is the use of a two-stage model to limit any effects of the tariff measure on growth through channels other than trade itself. This approach is designed to cope with the problem of linkage between policy measures. A trade policy is rarely implemented in isolation and typically trade liberalisation might occur at the same time as other macroeconomic liberalisation measures, thus a tariff measure may also act as a proxy for other policy measures. Limiting the effect of the tariff measure through the value of trade does not entirely eliminate this problem. It might still be the case that increased trade and growth were influenced by other macroeconomic policies implemented simultaneously with trade policy, but it is very likely that tariff itself will be a primary driver of any effect on growth through trade.

A time variable is included in all analyses to ensure that time based trends do not cause spurious correlations. Independent variables are lagged by one year to help ensure that there is causality in the right direction and fixed effects are included, variables are converted into log form where possible (in the absence of negative values).

4.0 Results

At the most simplistic level there is a negative correlation between Effective Tariff and Income Growth in a fixed effects panel regression with a time trend, as shown in Table 4.1. The coefficient of Effective Tariff in this simple equation is significant at the 5% level and is negative, as would be expected.

Table 4.1: Result of regression of Income Growth and Effective Tariff

```
. xtreg incomegrowth time l.effectivetariff, fe

Fixed-effects (within) regression               Number of obs      =      2841
Group variable: country                         Number of groups   =       140

R-sq:  within  = 0.0232                         Obs per group: min =         2
       between = 0.3649                                        avg =      20.3
       overall = 0.0482                                        max =        33

                                                F(2,2699)          =     32.12
corr(u_i, Xb)  = 0.1962                         Prob > F           =    0.0000

------------------------------------------------------------------------------
incomegrowth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .2136199   .0330927     6.46   0.000     .1487303    .2785095
             |
effectivet~f |
         L1. |   -.085727   .0437324    -1.96   0.050    -.1714794    .0000254
             |
       _cons |  -3.373642   1.397324    -2.41   0.016    -6.113575   -.6337093
-------------+----------------------------------------------------------------
     sigma_u |  4.7712811
     sigma_e |  12.812893
         rho |  .12178074   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(139, 2699) =     1.27           Prob > F = 0.0211
```

When the variables are converted into log form, the change in log income is compared to the log of Effective Tariff (the percentage tariff is taken as a number, such that a 6% tariff is represented by 6, and 1 is added to this number such that the log of zero tariff is also zero). In log form the coefficient of Effective Tariff is no longer significant, as shown in column 2 in Table 4.2. Further growth explanatory variables are now added to the equation, first log of income level then savings/GDP ratio, Foreign Direct Investment/GDP ratio and Foreign Aid/GDP ratio. Log per Capita Income is highly significant and with a negative coefficient, supporting the existence of conditional convergence between countries. In the presence of per capita income the coefficient of Log Effective Tariff becomes significant and remains so with the addition of further variables. Savings, FDI and aid all have significant positive coefficients in the combined equation. These results are shown in columns 2 to 5 of Table 4.2 and in full in Appendix 1.

Table 4.2: Dynamic Growth Equations

	1	2	3	4	5	6
Equation Type	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	Instrumented Fixed Effects
Dependent Variable	Change in Log Income	Change in Log Income	Change in Log Income	Change in Log Income	Change in Log Income	Change in Log Income
Log Effective Tariff (1 year lag)	Coeff -0.008 P 0.220 Z -1.23	Coeff -0.024 P 0.001 Z -3.46 Sig ***	Coeff -0.023 P 0.001 Z -3.27 Sig ***	Coeff -0.021 P 0.003 Z -3.00 Sig ***	Coeff -0.022 P 0.010 Z -2.58 Sig ***	
Log per Capita Income (1 year lag)		Coeff -0.085 P 0.000 Z -10.16 Sig ***	Coeff -0.091 P 0.000 Z -10.35 Sig ***	Coeff -0.096 P 0.000 Z -10.83 Sig ***	Coeff -0.094 P 0.000 Z -8.60 Sig ***	Coeff -0.096 P 0.000 Z -8.19 Sig ***
Savings/GDP ratio (1 year lag)			Coeff +3.391 P 0.000 Z +7.72 Sig ***	Coeff +3.604 P 0.000 Z +8.20 Sig ***	Coeff +3.333 P 0.000 Z +6.79 Sig ***	Coeff +1.692 P 0.039 Z +2.07 Sig **
FDI/GDP Ratio (1 year lag)				Coeff +0.011 P 0.631 Z +0.48	Coeff +0.314 P 0.006 Z +2.74 Sig ***	Coeff +0.083 P 0.502 Z +0.67
Aid/GDP Ratio (1 year lag)					Coeff +0.274 P 0.006 Z +2.74 Sig ***	Coeff +0.180 P 0.091 Z +1.69 Sig *
Log Trade/GDP Ratio (1 year lag)						Coeff +0.157 P 0.016 Z +2.42 Sig **
Time Trend	Coeff +0.002 P 0.000 Z +5.80 Sig ***	Coeff +0.003 P 0.000 Z +7.21 Sig ***	Coeff +0.003 P 0.000 Z +6.64 Sig ***	Coeff +0.003 P 0.000 Z +7.01 Sig ***	Coeff +0.003 P 0.000 Z +5.34 Sig ***	Coeff +0.002 P 0.114 Z +1.58
Instruments						Log Effective Tariff (2 year lag)
Observations	2841	2841	2697	2670	2004	1989
Number of Countries	140	140	134	134	112	112
R squared	0.05	0.00	0.00	0.00	0.01	0.03

Column 5 shows Effective Tariff having a negative coefficient which is significant at the 1% level, implying that Effective Tariff has a negative impact on income growth. A weakness of the analysis in column 5 is that tariffs might be decided as part of a range of macroeconomic policy decisions, thus level of tariff might be acting as a proxy for other macroeconomic policy decisions which might themselves affect income growth through channels other than trade. This equation therefore doesn't reliably isolate the tariff-growth link from other policy-growth effects. To narrow down the possible effects that are included in the equation a two-stage least squares approach is used with Effective Tariff now being entered as an instrument for the ratio of Trade to GDP, this two-stage equation is shown in column 6 of Table 4.2. This approach ensures that only policy effects that work through trade are taken into account. It is likely that tariff will be the main policy influencing trade and therefore this equation will largely isolate tariff effects from the impact of other macroeconomic policy decisions. To ensure the correct direction of causality Log Effective Tariff is lagged by a further year, such that the tariff level from two years ago influences the trade level from one year ago which influences the income growth up to the current year.

The equation shows a positive coefficient for Trade/GDP ratio that is significant at the 5% level, suggesting that trade policy is indeed having an influence on income growth and showing strong support for the existence of dynamic gains from trade. An important question is whether this finding is applicable to both developed and developing countries. To answer this point the Aid/GDP term was removed (since it is irrelevant to developed countries) and the sample split into two. The results of this analysis are shown in Table 4.3 and full results in Appendix 2. The results in Table 4.3 show very similar performance of the trade term in the two equations, which suggests that tariffs and trade have a similar effect on countries at different stages of development.

Table 4.3: Instrumented Equations by Country Level of Development

	1	2	3
Equation Type	Instrumented Fixed Effects	Instrumented Fixed Effects	Instrumented Fixed Effects
Dependent Variable	Change in Log Income	Change in Log Income	Change in Log Income
Sample	All Countries	Developed Countries Only	Developing Countries Only
Log per Capita Income (one year lag)	Coeff -0.102 P 0.000 Z -10.20 Sig ***	Coeff -0.111 P 0.000 Z -5.20 Sig ***	Coeff -0.104 P 0.000 Z -8.67 Sig ***
Savings/GDP ratio (one year lag)	Coeff +2.016 P 0.003 Z +3.00 Sig ***	Coeff +3.627 P 0.014 Z +2.46 Sig **	Coeff +1.709 P 0.024 Z +2.26 Sig **
FDI/GDP ratio (one year lag)	Coeff +0.011 P 0.880 Z +0.15	Coeff -0.045 P 0.571 Z -0.57	Coeff +0.066 P 0.608 Z +0.51
Log Trade/GDP Ratio (one year lag)	Coeff +0.158 P 0.001 Z +3.20 Sig ***	Coeff +0.228 P 0.005 Z +2.78 Sig ***	Coeff +0.147 P 0.006 Z +2.76 Sig ***
Time Trend	Coeff +0.002 P 0.035 Z +2.11 Sig **	Coeff +0.002 P 0.108 Z +1.61	Coeff +0.001 P 0.124 Z +1.54
Instruments	Log Effective Tariff (two year lag)	Log Effective Tariff (two year lag)	Log Effective Tariff (two year lag)
Observations	2669	809	1750
Number of Countries	134	35	87
R squared	0.01	0.04	0.02

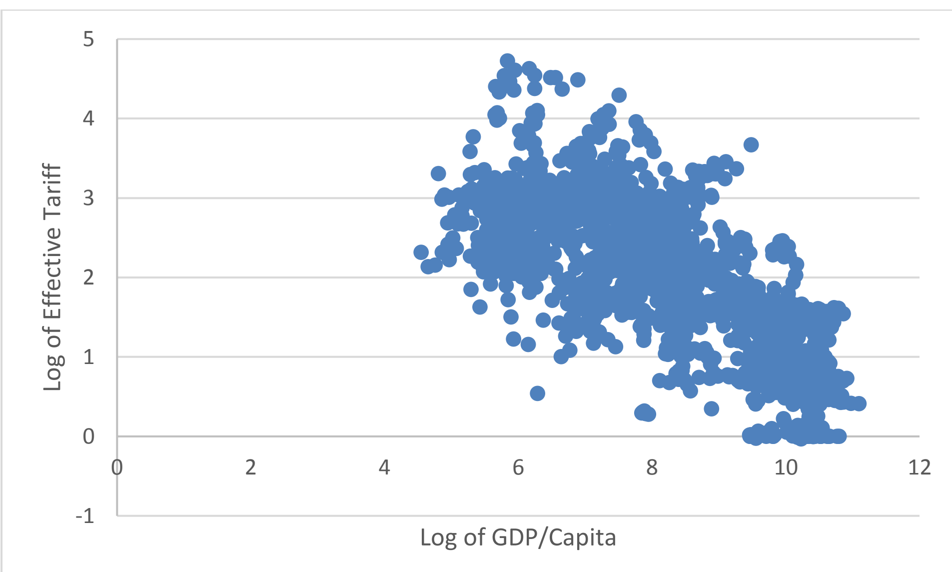
5.0 Discussion

The results from this study reinforce the findings of previous studies that there are strong dynamic gains from trade and that these are connected to trade policy. Column 1 of Table 4.2 showed a coefficient for Effective Tariff of -0.09, suggesting that a reduction in tariffs of 11% might increase income growth by 1%. A tariff level of 11% is typical for Sub-Saharan African countries, implying that removal of their tariffs might lead to a 1% gain in income growth and this finding is similar to the 1.5% income growth found by Wacziarg and Welch (2003) between open and closed economies in Figure 3.1. The empirical evidence seems to be consistent that tariffs have a major impact on growth rates.

As discussed in Section 2.0 there isn't a very satisfactory mechanism in existing growth theories to incorporate this impact of trade policy on growth. Nordas at al (2006) have proposed that the mechanism of technology spill-over from trade might be responsible (row 4 in Figure 1.1), but it seems unlikely that spill-overs alone could produce such a high impact on growth. A second problem with the spill-over approach is that significant technology spill-overs are only likely to occur within developing countries when trading with developed countries. The similar findings for developed and developing countries in Table 4.3 do not bear this out. It is also the case that the highest trade growth in recent years has been of intra-industry trade between developed countries, leading to faster growth of trade between OECD countries than between OECD countries and developing countries. It does not seem likely that technology spill-over can fully explain these observed trade developments and the results of empirical analysis.

A more likely explanation of the dynamic gains from trade would appear to be row 3 in Figure 1.1, specialisation. Smith and Ricardo's original arguments for trade were clearly based on the benefits of specialisation and there is a strong intuitive reason to suppose that trade will bring significantly increased specialisation, especially for smaller economies. This specialisation explanation for dynamic gains has the advantage that it would be applicable to any country trading with any other country. The rise of intra-industry trade can also therefore be taken into account and its implication for growth understood. The problem then is not that dynamic gains from trade cannot be explained, it is that there is no satisfactory way to incorporate specialisation benefits from trade into existing growth equations. There is therefore a need to alter the theory to suit the evidence.

Figure 5.1: Scatter Plot of Effective Tariff and Income



The modification necessary to growth theories to allow dynamic gains from trade is that specialisation and technology must be considered as the joint drivers of productivity and hence output, lack of either can restrict growth. Large economies that are well linked into the global trading system will tend to need technological advances to grow their incomes, whilst smaller, less well linked, economies will increase their growth if they permit more trade, hence allowing greater specialisation. Figure 5.1 shows a scatter diagram of countries. Countries to the bottom right have high incomes together with good access to global markets for trade and will need technology improvements to increase growth, whilst countries in the top left of the plot have lower incomes with poorer access to global markets and what they need most is removal of their own tariff barriers to allow greater trade and hence specialisation.

6.0 Conclusion

This study made data, measurement and methodology improvements over previous empirical work:

- The use of a larger dataset, allowing annual analysis
- Identification of Effective Tariff as the best numerical measure of trade policy
- Use of two-stage least squares analysis to identify only trade policy to trade value to growth linkages

The results from this study confirm previous empirical findings:

- There are dynamic growth gains from liberalisation of trade policy
- These gains are large, in the order of 1% per annum income growth for developing countries

The literature review showed that it is difficult to fit these results into the mechanisms of current growth equations. This study concludes that the technology term in existing growth equations needs to be broadened to include specialisation, which would allow trade to be incorporated into growth equations.

References:

Cadbury, M. (2016) *Trade Policy and Trade Flows. An Empirical Investigation*. FREIT working papers 1115.

Grossman, G. (2016) *The Purpose of Trade Agreements*. NBER Working Paper 22070.

Nordas, H. Miroudot, S. and Kowalski, P. (2006) *Dynamic Gains from Trade*. OECD Policy Papers. ISSN 1816-6873.

Ricardo, D. (1817) *The Principles of Political Economy and Taxation*. Chapter 7, 7.16 Library of Economics and liberty, http://www.econlib.org/library/Ricardo/ricP2a.html#Ch.7,%20On%20Foreign%20Trade

Schularick, M. and Solomou, S. (2011) Tariffs and Economic Growth in the First Era of Globalisation. *Journal of Economic Growth*. Vol 16. Issue 1. pp. 33-70.

Singh, T. (2010) 'Does International Trade Cause Economic Growth? A Survey'. *The World Economy*. Vol 33. Issue 11.

Smith, A. (1776) *The Wealth of Nations*. Edited by Andrew Skinner 1999. London: Penguin books.

Wacziarg, R. and Welch, K. (2003) *Trade Liberalization and Growth: New Evidence*, National Bureau of Economic Research working paper 10152, Cambridge, MA.

World Bank (1987) *World Bank Development Report 1987*. Oxford University Press. ISBN 0-19-520562-6. p83.

Appendix 1

```
. xtreg incomegrowth time, fe

Fixed-effects (within) regression               Number of obs      =      7334
Group variable: country                         Number of groups   =       182

R-sq:  within  = 0.0009                         Obs per group: min =        10
       between = 0.0653                                        avg =      40.3
       overall = 0.0016                                        max =        50

                                                F(1,7151)          =      6.24
corr(u_i, Xb)  = 0.0465                         Prob > F           =    0.0125

------------------------------------------------------------------------------
incomegrowth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0327497    .013111     2.50   0.013     .0070483    .0584511
       _cons |   2.554772   .4195778     6.09   0.000     1.732275    3.377268
-------------+----------------------------------------------------------------
     sigma_u |  3.0092096
     sigma_e |  14.778103
         rho |  .03981286   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(181, 7151) =     1.40           Prob > F = 0.0004

. xtreg incomegrowth time l.effectivetariff, fe

Fixed-effects (within) regression               Number of obs      =      2841
Group variable: country                         Number of groups   =       140

R-sq:  within  = 0.0232                         Obs per group: min =         2
       between = 0.3649                                        avg =      20.3
       overall = 0.0482                                        max =        33

                                                F(2,2699)          =     32.12
corr(u_i, Xb)  = 0.1962                         Prob > F           =    0.0000

------------------------------------------------------------------------------
incomegrowth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .2136199   .0330927     6.46   0.000     .1487303    .2785095
             |
effectivet~f |
         L1. |   -.085727   .0437324    -1.96   0.050    -.1714794    .0000254
             |
       _cons |  -3.373642   1.397324    -2.41   0.016    -6.113575   -.6337093
-------------+----------------------------------------------------------------
     sigma_u |  4.7712811
     sigma_e |  12.812893
         rho |  .12178074   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(139, 2699) =     1.27           Prob > F = 0.0211
```

```
. xtreg chlogpercapitaincome time l.logeffectivetariff, fe

Fixed-effects (within) regression               Number of obs      =      2841
Group variable: country                         Number of groups   =       140

R-sq:  within  = 0.0236                         Obs per group: min =         2
       between = 0.4116                                        avg =      20.3
       overall = 0.0485                                        max =        33

                                                F(2,2699)          =     32.56
corr(u_i, Xb)  = 0.2194                         Prob > F           =    0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0022036   .0003799     5.80   0.000     .0014586    .0029486
             |
logeffecti~f |
         L1. |  -.0084511   .0068924    -1.23   0.220    -.0219661    .0050639
             |
       _cons |  -.0370441   .0239378    -1.55   0.122    -.0839823    .0098941
-------------+----------------------------------------------------------------
     sigma_u |  .04351347
     sigma_e |  .12963303
         rho |  .10126259   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(139, 2699) =     1.06           Prob > F = 0.2959

. xtreg chlogpercapitaincome time l.logeffectivetariff l.logpercapitaincome, fe

Fixed-effects (within) regression               Number of obs      =      2841
Group variable: country                         Number of groups   =       140

R-sq:  within  = 0.0595                         Obs per group: min =         2
       between = 0.0000                                        avg =      20.3
       overall = 0.0013                                        max =        33

                                                F(3,2698)          =     56.91
corr(u_i, Xb)  = -0.9223                        Prob > F           =    0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0027117   .0003763     7.21   0.000     .0019739    .0034496
             |
logeffecti~f |
         L1. |  -.0239933   .0069366    -3.46   0.001    -.0375949   -.0103918
             |
logpercapi~e |
         L1. |  -.0847365   .0083443   -10.16   0.000    -.1010984   -.0683746
             |
       _cons |   .6626357   .0727965     9.10   0.000     .5198931    .8053782
-------------+----------------------------------------------------------------
     sigma_u |  .13065228
     sigma_e |  .12724799
         rho |  .51319774   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(139, 2698) =     1.80           Prob > F = 0.0000
```

```
. xtreg chlogpercapitaincome time l.logeffectivetariff l.logpercapitaincome l.savin
> gsgdp, fe

Fixed-effects (within) regression               Number of obs      =      2697
Group variable: country                         Number of groups   =       134

R-sq:  within  = 0.0756                         Obs per group: min =         1
       between = 0.0069                                        avg =      20.1
       overall = 0.0042                                        max =        33

                                                F(4,2559)          =     52.31
corr(u_i, Xb)  = -0.9120                        Prob > F           =    0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |    .002501   .0003874     6.46   0.000     .0017413    .0032607
             |
logeffecti~f |
         L1. |  -.0230972   .0070646    -3.27   0.001      -.03695   -.0092443
             |
logpercapi~e |
         L1. |  -.0905947   .0087563   -10.35   0.000    -.1077648   -.0734246
             |
  savingsgdp |
         L1. |   3.390983   .4391615     7.72   0.000     2.529835    4.252131
             |
       _cons |   .6503686   .0755724     8.61   0.000     .5021793    .7985579
-------------+----------------------------------------------------------------
     sigma_u |  .12043952
     sigma_e |  .12569506
         rho |  .47865742   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(133, 2559) =     1.90           Prob > F = 0.0000

. xtreg chlogpercapitaincome time l.logeffectivetariff l.logpercapitaincome l.savin
> gsgdp l.fdigdp, fe

Fixed-effects (within) regression               Number of obs      =      2670
Group variable: country                         Number of groups   =       134

R-sq:  within  = 0.0830                         Obs per group: min =         1
       between = 0.0016                                        avg =      19.9
       overall = 0.0035                                        max =        33

                                                F(5,2531)          =     45.83
corr(u_i, Xb)  = -0.9183                        Prob > F           =    0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0027428   .0003914     7.01   0.000     .0019753    .0035103
             |
logeffecti~f |
         L1. |   -.021174   .0070538    -3.00   0.003    -.0350058   -.0073422
             |
logpercapi~e |
         L1. |  -.0957422   .0088384   -10.83   0.000    -.1130735   -.0784109
             |
  savingsgdp |
         L1. |     3.6041   .4396083     8.20   0.000     2.742072    4.466129
             |
      fdigdp |
         L1. |   .0114565   .0238808     0.48   0.631    -.0353714    .0582844
             |
       _cons |   .6765058   .0759576     8.91   0.000     .5275604    .8254512
-------------+----------------------------------------------------------------
     sigma_u |  .13057271
     sigma_e |  .12494536
         rho |   .5220126   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(133, 2531) =     2.04           Prob > F = 0.0000
```

```
. xtreg chlogpercapitaincome time l.logeffectivetariff l.logpercapitaincome l.savin
> gsgdp l.fdigdp l.aidgdp, fe

Fixed-effects (within) regression               Number of obs      =      2004
Group variable: country                         Number of groups   =       112

R-sq:  within  = 0.0972                         Obs per group: min =         1
       between = 0.0006                                        avg =      17.9
       overall = 0.0098                                        max =        33

                                                F(6,1886)          =     33.86
corr(u_i, Xb)  = -0.8645                        Prob > F           =    0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        time |   .0026046    .000488     5.34   0.000     .0016476    .0035616
             |
logeffecti~f |
         L1. |  -.0216544   .0084001    -2.58   0.010    -.0381288    -.00518
             |
logpercapi~e |
         L1. |  -.0944947   .0109875    -8.60   0.000    -.1160437   -.0729456
             |
  savingsgdp |
         L1. |   3.333205   .4912305     6.79   0.000     2.369793    4.296617
             |
      fdigdp |
         L1. |   .3140601   .1144239     2.74   0.006     .0896495    .5384708
             |
      aidgdp |
         L1. |   .2735547   .0999072     2.74   0.006     .0776145     .469495
             |
       _cons |   .6056158   .0934679     6.48   0.000     .4223043    .7889272
-------------+----------------------------------------------------------------
     sigma_u |  .11908255
     sigma_e |  .13061339
         rho |  .45391873   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(111, 1886) =     1.91           Prob > F = 0.0000
```

```
. xtivreg chlogpercapitaincome time l.logpercapitaincome l.savingsgdp l.fdigdp l.ai
> dgdp (l.logtradegdp=l2.logeffectivetariff), fe

Fixed-effects (within) IV regression         Number of obs      =       1989
Group variable: country                      Number of groups   =        112

R-sq:  within  = 0.1310                      Obs per group: min =          2
       between = 0.0123                                     avg =       17.8
       overall = 0.0260                                     max =         33

                                             Wald chi2(6)       =     279.43
corr(u_i, Xb)  = -0.8402                     Prob > chi2        =     0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 logtradegdp |
         L1. |   .1569437   .0649584     2.42   0.016     .0296275    .2842599
             |
        time |   .0015874   .0010035     1.58   0.114    -.0003794    .0035543
             |
logpercapi~e |
         L1. |  -.0956511   .0116852    -8.19   0.000    -.1185538   -.0727485
             |
  savingsgdp |
         L1. |   1.691711   .8177595     2.07   0.039     .0889316     3.29449
             |
      fdigdp |
         L1. |   .0833303   .1241889     0.67   0.502    -.1600754     .326736
             |
      aidgdp |
         L1. |   .1802987   .1067017     1.69   0.091    -.0288327    .3894301
             |
       _cons |   .0249192    .258675     0.10   0.923    -.4820745    .5319128
-------------+----------------------------------------------------------------
     sigma_u |  .12492628
     sigma_e |  .12913832
         rho |  .48342596   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F  test that all u_i=0:     F(111,1871) =     2.39        Prob > F    = 0.0000
------------------------------------------------------------------------------
Instrumented:   L.logtradegdp
Instruments:    time L.logpercapitaincome L.savingsgdp L.fdigdp L.aidgdp
                L2.logeffectivetariff
------------------------------------------------------------------------------

.
```

Appendix 2

```
. xtivreg chlogpercapitaincome time l.logpercapitaincome l.savingsgdp l.fdigdp (l.l
> ogtradegdp=l2.logeffectivetariff), fe

Fixed-effects (within) IV regression         Number of obs      =       2669
Group variable: country                      Number of groups   =        134

R-sq:  within  = 0.1153                      Obs per group: min =          2
       between = 0.0088                                     avg =       19.9
       overall = 0.0090                                     max =         33

                                             Wald chi2(5)       =     375.43
corr(u_i, Xb)  = -0.9278                     Prob > chi2        =     0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 logtradegdp |
         L1. |    .158055   .0493309     3.20   0.001     .0613681    .2547419
             |
        time |   .0015538   .0007372     2.11   0.035     .0001088    .0029987
             |
logpercapi~e |
         L1. |  -.1017679   .0099754   -10.20   0.000    -.1213194   -.0822164
             |
  savingsgdp |
         L1. |   2.016247   .6714897     3.00   0.003     .7001517    3.332343
             |
      fdigdp |
         L1. |   .0108554    .072117     0.15   0.880    -.1304912    .1522021
             |
       _cons |   .1401857   .2108857     0.66   0.506    -.2731427    .5535142
-------------+----------------------------------------------------------------
     sigma_u |  .15817201
     sigma_e |  .12434276
         rho |  .61805062   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F  test that all u_i=0:     F(133,2530) =     2.82       Prob > F    = 0.0000
------------------------------------------------------------------------------
Instrumented:   L.logtradegdp
Instruments:    time L.logpercapitaincome L.savingsgdp L.fdigdp
                L2.logeffectivetariff
------------------------------------------------------------------------------
```

```
. xtivreg chlogpercapitaincome time l.logpercapitaincome l.savingsgdp l.fdigdp (l.l
> ogtradegdp=l2.logeffectivetariff) if ddeveloped==1, fe

Fixed-effects (within) IV regression         Number of obs      =          809
Group variable: country                      Number of groups   =           35

R-sq:  within  = 0.0560                      Obs per group: min =            3
       between = 0.5602                                     avg =         23.1
       overall = 0.0441                                     max =           33

                                             Wald chi2(5)       =       155.14
corr(u_i, Xb)  = -0.9586                     Prob > chi2        =       0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 logtradegdp |
         L1. |   .2284635   .0822721     2.78   0.005     .0672131    .3897138
             |
        time |   .0020399   .0012685     1.61   0.108    -.0004463    .0045262
             |
logpercapi~e |
         L1. |  -.1108644   .0213214    -5.20   0.000    -.1526536   -.0690752
             |
  savingsgdp |
         L1. |   3.627023   1.474611     2.46   0.014     .7368397    6.517207
             |
      fdigdp |
         L1. |  -.0450233   .0793772    -0.57   0.571    -.2005998    .1105531
             |
       _cons |   .0791391   .4062136     0.19   0.846     -.717025    .8753031
-------------+----------------------------------------------------------------
     sigma_u |  .15225121
     sigma_e |  .10864788
         rho |  .66258593   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F  test that all u_i=0:     F(34,769) =     1.85         Prob > F    = 0.0026
------------------------------------------------------------------------------
Instrumented:   L.logtradegdp
Instruments:    time L.logpercapitaincome L.savingsgdp L.fdigdp
                L2.logeffectivetariff
------------------------------------------------------------------------------

.
```

```
. xtivreg chlogpercapitaincome time l.logpercapitaincome l.savingsgdp l.fdigdp (l.l
> ogtradegdp=l2.logeffectivetariff) if ddeveloping==1, fe

Fixed-effects (within) IV regression         Number of obs      =      1750
Group variable: country                      Number of groups   =        87

R-sq:  within  = 0.1280                      Obs per group: min =         2
       between = 0.0021                                     avg =      20.1
       overall = 0.0246                                     max =        33

                                             Wald chi2(5)       =    223.03
corr(u_i, Xb)  = -0.8547                     Prob > chi2        =    0.0000

------------------------------------------------------------------------------
chlogperca~e |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 logtradegdp |
         L1. |    .147115   .0533829     2.76   0.006     .0424864    .2517435
             |
        time |   .0012692   .0008261     1.54   0.124      -.00035    .0028883
             |
logpercapi~e |
         L1. |  -.1040358    .011999    -8.67   0.000    -.1275534   -.0805182
             |
  savingsgdp |
         L1. |   1.709211   .7572903     2.26   0.024      .224949    3.193472
             |
      fdigdp |
         L1. |   .0659636   .1287462     0.51   0.608    -.1863742    .3183015
             |
       _cons |   .1381288   .2241609     0.62   0.538    -.3012184     .577476
-------------+----------------------------------------------------------------
     sigma_u |  .12405481
     sigma_e |  .12882167
         rho |  .48115615   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F  test that all u_i=0:     F(86,1658) =     2.48         Prob > F    = 0.0000
------------------------------------------------------------------------------
Instrumented:   L.logtradegdp
Instruments:    time L.logpercapitaincome L.savingsgdp L.fdigdp
                L2.logeffectivetariff
------------------------------------------------------------------------------
```